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AXIALLY DISTORTED 3-3 COMPOSITE

FOR

HYDROPHONE APPLICATIONS

Department of the Navy
Grant No.: N00014-92-J-4025

PROGRESS REPORT

for the period of
September-December 1992

Submitted to:

Office of Naval Research
and
Naval Research Laboratory

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1.0 SUMMARY

During the period from September to December 1992, progress has been made in initiating contact with the subcontractor, Hi Tech Ceramics, Inc., literature surveys, and in material and supply procurement. This includes design and fabrication of test and evaluation equipment and raw material purchase. A foam distortion technique which will allow repeatable and measurable modification of the foam macrostructure has been identified. An apparatus for evaluation of the distortion parameters has been fabricated and is nearly ready for testing. Some qualitative macroscopic evaluations of a distorted foam have also been made. A test chamber in which the hydrostatic response of the composite samples up to 1000 psi has been designed and fabricated. Problems with the raw material supplier have caused a significant delay in delivery of the PZT powder which has severely impacted the baseline sample fabrication schedule. Only a partial shipment has been received to date.

2. PROGRAMMATIC ISSUES

2.1 Subcontractor Coordination:

Coordination with Hi Tech Ceramics, Inc. of Alfred, NY has been established. A meeting was held in which the role of Hi Tech Ceramics was defined. In addition to support of the foam distortion studies, they are to provide a set of baseline (undistorted) reticulated PZT green ceramic samples which will be fired at New York State College of Ceramics (NYSCC). Distorted foam material will be supplied to Hi Tech Ceramics and will be used to fabricate more green ceramic samples. All foam distortion, firing, and sample evaluation will be performed at NYSCC. Formulation of the slurry must be performed at Hi Tech Ceramics, Inc. due to the proprietary nature of the process. The baseline sample fabrication has been severely impacted by the delay in delivery of the PZT powder from Morgan Matroc, Inc..

2.2 PZT Powder Purchase:

The PZT raw material supplier, Morgan Matroc, Inc., has had significant difficulty in filling an order for 50 pounds placed in early November. A 10 pound lot of PZT-5H was received late in December, the remainder (part of a different lot) to be shipped as it becomes available. In addition, the material in the 10 pound lot is quoted by the supplier as having a d_{33} approximately 100 pC/N lower than specification due to problems in processing. The powder will be used as-is since the first few pounds will most likely be sacrificed during slurry formulation development at Hi Tech Ceramics, Inc.. We have been assured that the remainder of the powder will be within normal specifications.

3.0 TECHNICAL PROGRESS

3.1 Literature Survey:

A survey of available literature on fabrication of 3-3 composites indicates that the technique of using the reticulated ceramic structure for fabrication of piezoelectric composites is still untried. Other methods which produce a similar macrostructure have been used but are not desirable from a manufacturing standpoint. The search for relevant literature is an ongoing process. Information pertaining to the mechanical performance of the reticulated ceramic structure is also being studied so that a model may be developed which describes the performance of this type composite.

3.2 Foam Distortion :

A method for controllably distorting the foam used in the manufacture of reticulated ceramics has been developed. The method involves simply stretching the foam at an elevated temperature. The foam is "pre-stretched" and then heated until the tensile stress is minimized. A fixture was fabricated which provides a means for setting the amount of pre-stretch. The fixture can then be placed in an oven and heated to the appropriate temperature. Preliminary tests indicate that this method will produce suitably distorted foam which can be used to fabricate the final composite samples. Figure 1 shows an example of a distorted foam macrostructure compared with the non-distorted material. Determination of the appropriate temperature has not been accomplished yet. An apparatus which will allow observation of the distortion as a function of temperature has been fabricated (see Figure 2). As the foam sample is heated, the onset of distortion caused by the weight of the LVDT core is detected by the LVDT. The LVDT will allow measurement of the amount of distortion as well. All of the parameters will be recorded and reduced by computer. Testing is planned for early January. Production of the distorted samples should coincide with the development of a suitable slurry at Hi Tech Ceramics, Inc. and their delivery of the baseline samples.

3.3 Test Equipment Fabrication:

A chamber to be used for hydrostatic testing of the composite samples has been designed and fabricated. The vessel is capable of testing at up 1000 psi. A piezoelectric displacement device will provide the variable frequency hydrostatic signal. This device was fabricated from material donated by Don Bonnema of EDO Corporation in Salt Lake City, Utah. This this device will also output information to the computer for easy reduction. The pressure instrumentation components are currently the only items not received. Since the chamber will not be used until composite samples are prepared, there is currently no anticipated schedule impact from the delayed items. Assembly and testing of the chamber should take place by February.

3.4 Composite Model Development:

The reticulated structure has certain characteristics which may make predictions of piezoelectric properties more difficult than with other composite structures. One reason for this is that the individual ligaments of the reticulated structure will be hollow.

This results from coating a plastic foam structure with ceramic and then burning out the plastic. Another source of difficulty in modeling comes from the geometry of the reticulated structure. The many angles and interconnections of the structure form a very complex network which may be difficult to analyze.

4.0 FUTURE WORK

The following activities are planned for the coming spring semester (period of January to May,1993).

4.1 Foam Distortion:

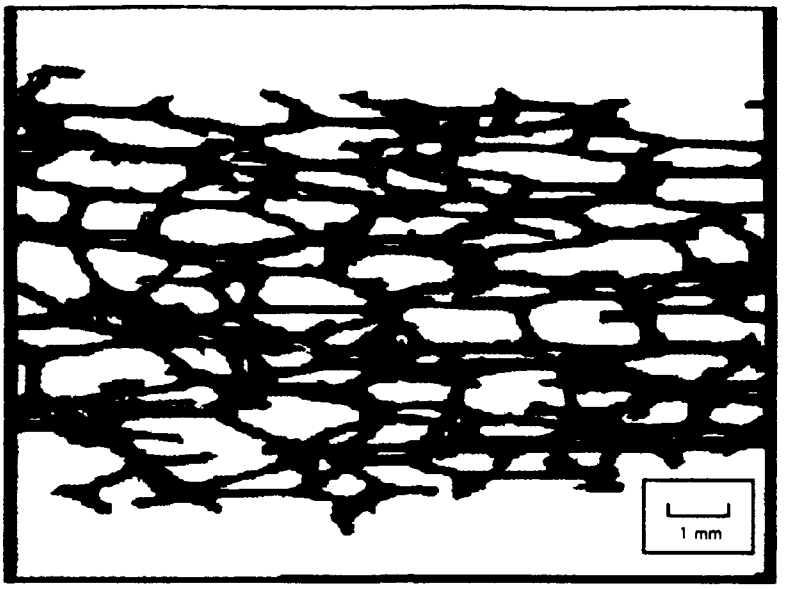
Early in the semester, characterization of the foam and preparation of the distorted foam material will be performed. Several different pore sizes of the distorted material will be delivered to Hi Tech Ceramics for preparation of the reticulated PZT.

4.2 Sample Fabrication and Characterization:

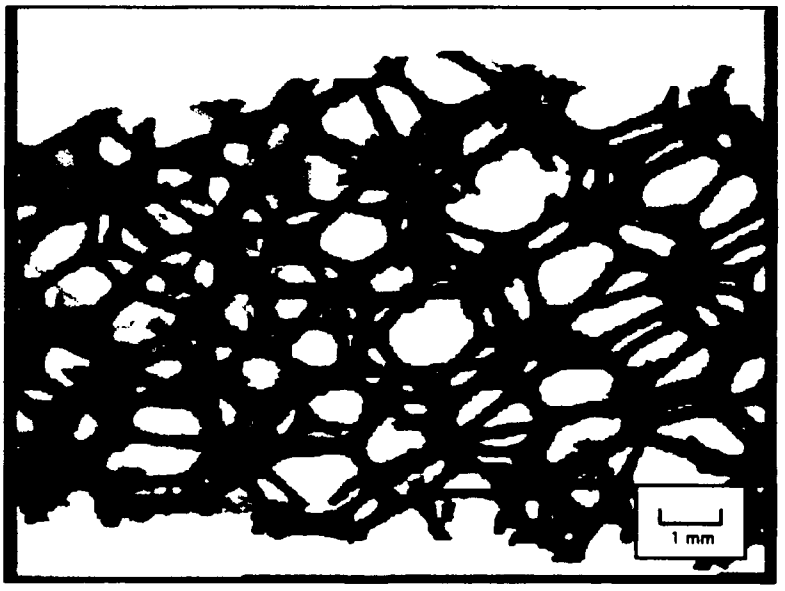
Upon delivery of the first lot of PZT powder to Hi Tech Ceramics, Inc. in early January, slurry development and baseline sample preparation will begin. Samples of unfired reticulated PZT of various pore sizes will be delivered. Distorted samples will also be fabricated during this period. Complete sample fabrication includes firing of the PZT and infiltration of the reticulated structure with a polymer. It is likely that several epoxies and an elastomer will be used. Since firing of reticulated ceramics involves a delicate burn-out process, a short development effort will be required at NYSCC to define the proper parameters. It is anticipated that there will only be time for basic characterization of the prepared samples during this period. This should include microscopic and macroscopic analysis and basic elctro-mechanical property measurements such as d_{33}, dielectric constant, and, possibly hydrostatic testing.

4.3 Composite Property Model Development:

Work on the development of a theoretical model for the composite properties will be performed. The plan includes attempting to use a simple a finite element model to predict the electro-mechanical properties of the composite material.



(a)



(b)

Figure 1. (a) Distorted 20 pore per inch foam
(b) Undistorted 20 pore per inch foam

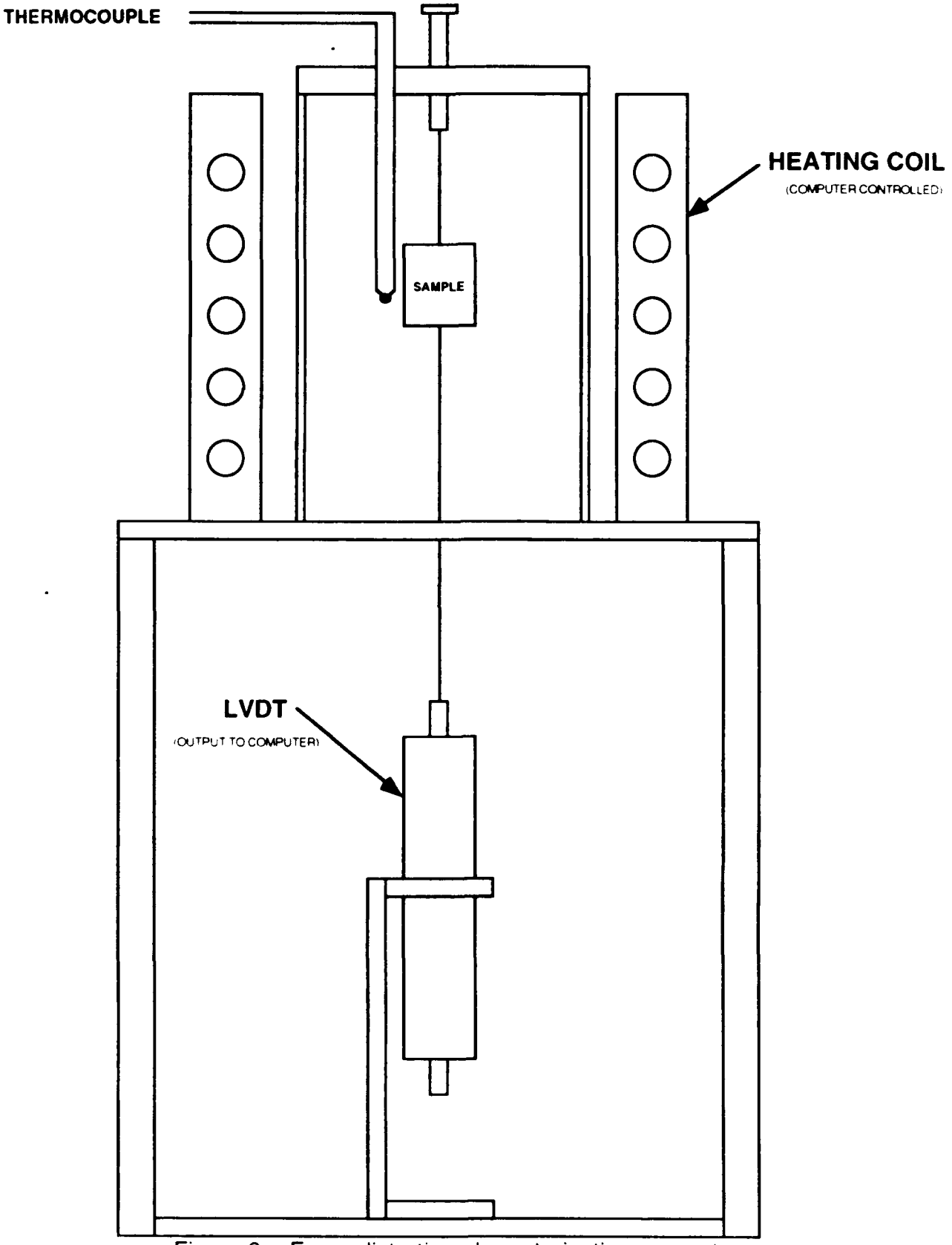


Figure 2. Foam distortion characterization apparatus.